



DS-2 MARS MICROPROBE BATTERY

H. FRANK, A. KINDLER, F. DELIGIANNIS, E. DAVIES,
J. BLANKEVOORT, B. V. RATNAKUMAR, AND S. SURAMPUDI

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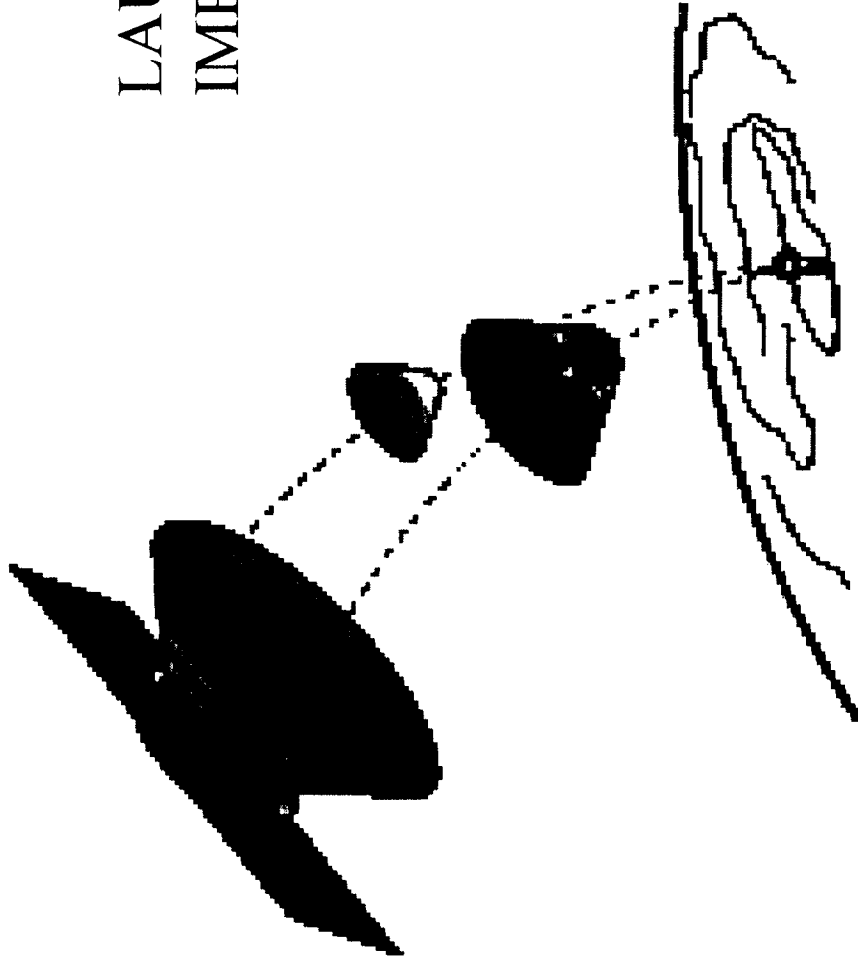


OUTLINE

- DS-2 MISSION OVERVIEW
- DS-2 BATTERY PERF. REQUIREMENTS
- BATTERY TECHNOLOGY CHALLENGES
- CHEMISTRY SELECTION
- CELL DESIGN OVERVIEW
- PROBLEMS ENCOUNTERED
- PERFORMANCE RESULTS
- CONCLUSIONS



NM DS-2 MISSION OVERVIEW



LAUNCH: JAN. 1999
IMPACT MARS: DEC. 1999



DS2 MISSION OBJECTIVES

TECHNICAL OBJECTIVES

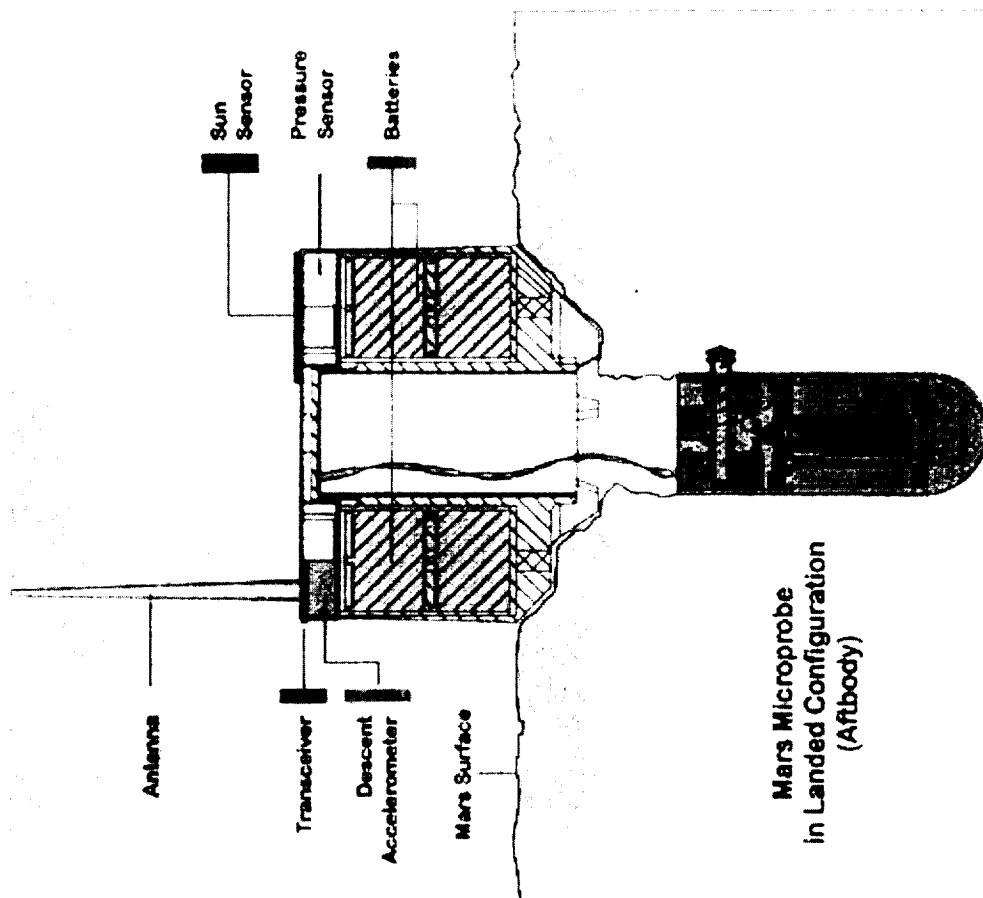
- Demonstrate key technologies which enable future network science missions (e.g., multiple landers, penetrators, or spacecraft)
- Demonstrate a passive atmospheric entry.
- Demonstrate highly integrated microelectronics which can withstand both low temperatures and high decelerations.
- Demonstrate in-situ, surface and subsurface science data acquisition

Scientific Objectives

- Determine if ice is present below the Martian surface
- Measure the local atmospheric pressure
- Characterize the thermal properties of the Martian subsurface soil
- Estimate the vertical temperature gradient of the Martian soil



DS-2 AFTBODY





DS-2 MARS MICROPROBE BATTERY



REQUIREMENTS

- Two 4 cell batteries
 - Battery Voltage: 6-14 V
 - Battery Capacity: 550 mAh at -80°C
2 Ah at 25° C
 - Shelf Life: 2.5 Years
 - Operating Temp.: -60 C and below
 - Shock Impact: 80,000 g
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Technology Challenges

- Ultra Low Temperature Operation(-80C)
- High Impact Shock Capability
- Minimal Voltage Delay at -60 C and below
- Three Year Shelf Life

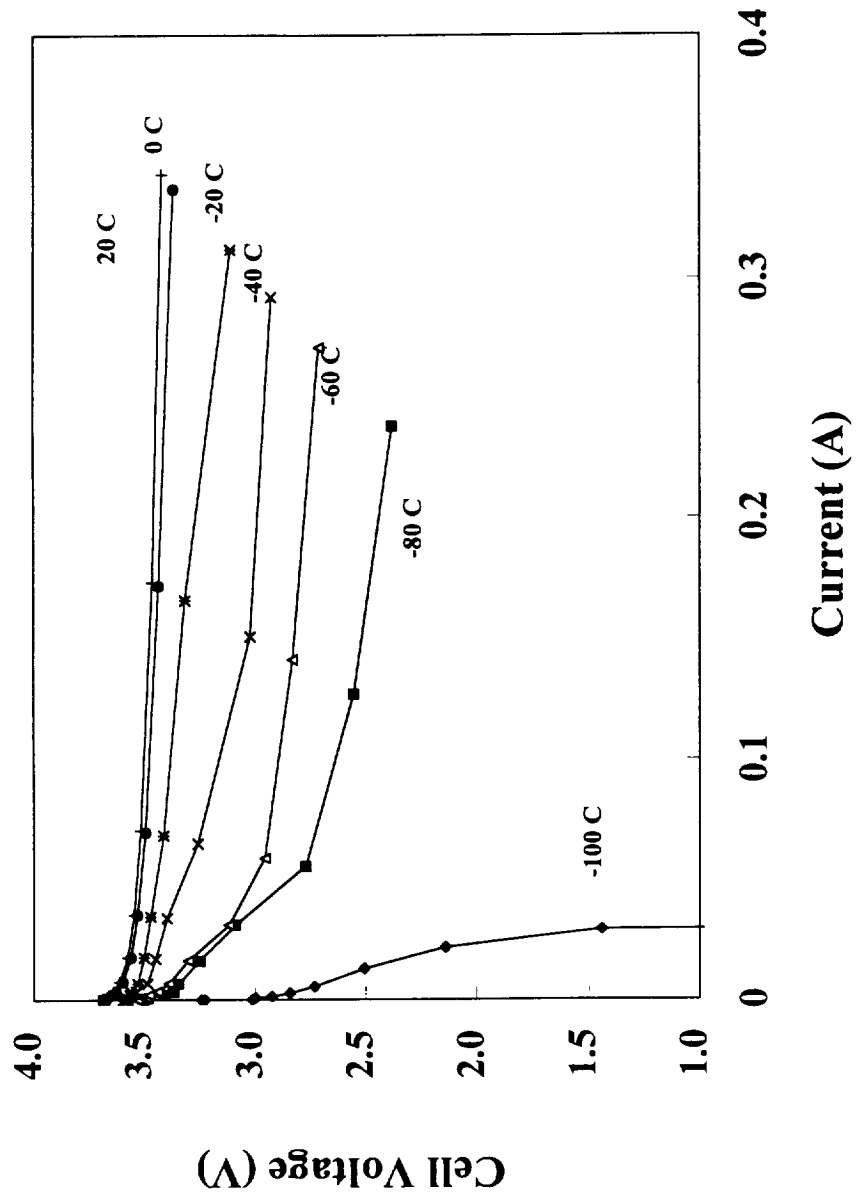


Technical Approach

- **Select Cell Chemistry**
- **Award Contract for Cell Fabrication**
- **Demonstrate Electrical Performance at -80C**
- **Demonstrate Impact Resistance**
- **Demonstrate Life (Microcal)**
- **Demonstrate Safety**
- **Deliver Quality Cells to Project**



DS 2 BATTERY Li-SOCL₂ SYSTEM



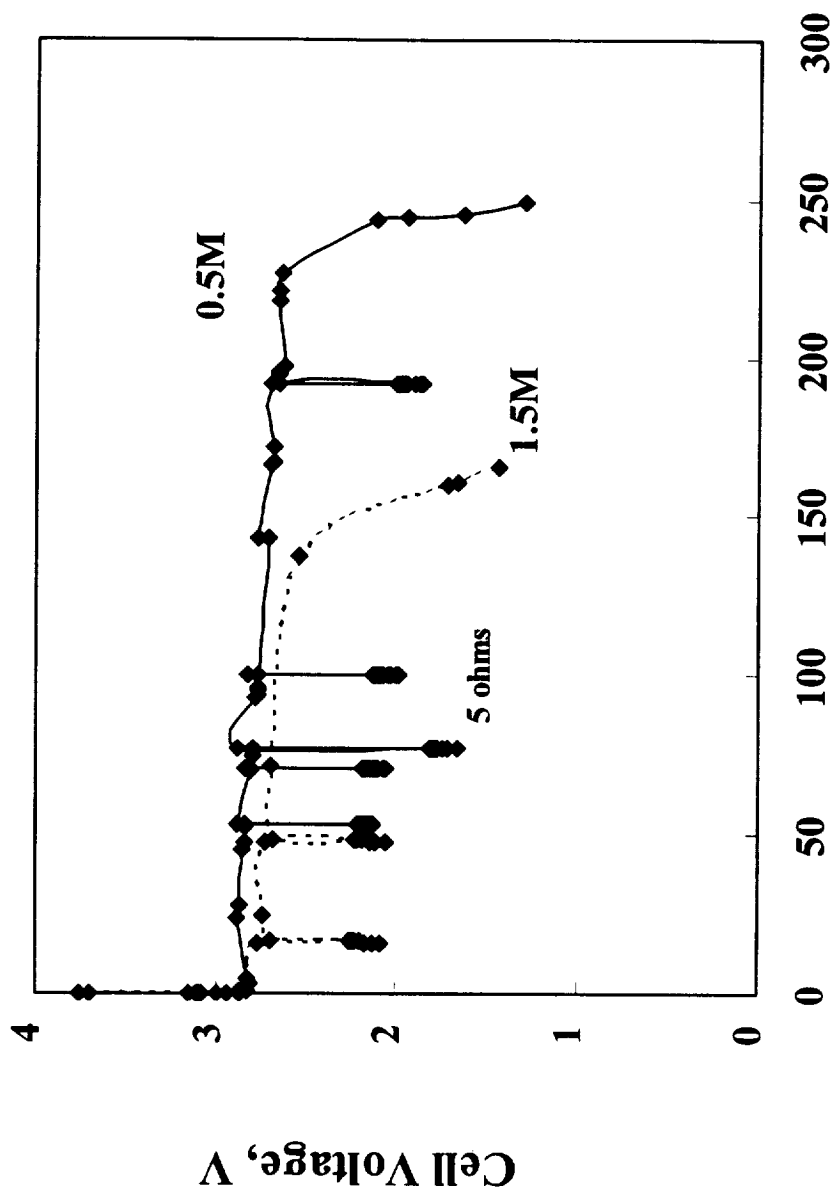
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Li-SOCl₂ CHEMISTRY DEVELOPMENT

Discharge curves of D-size Li-SOCl₂ Cell at -80°C at 120 ohm

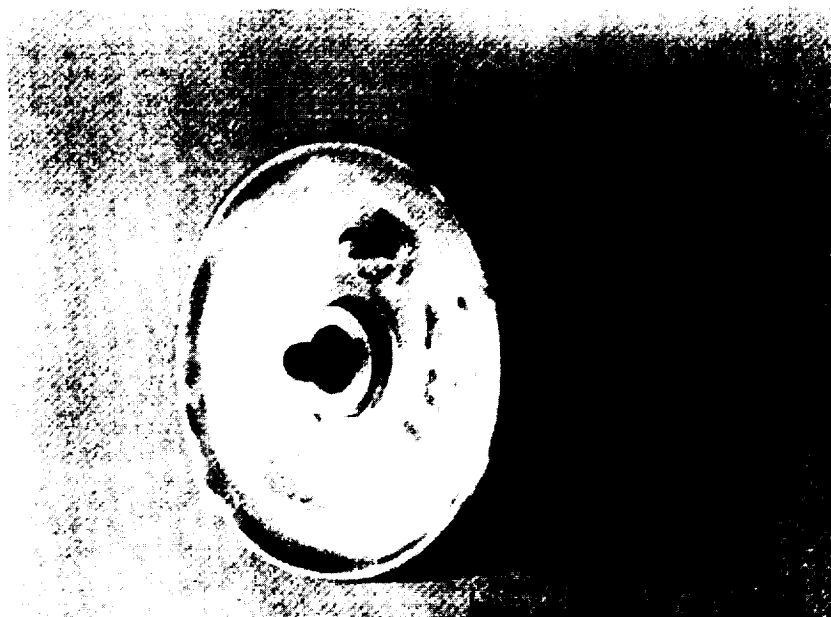


Discharge Time, h

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Ds-2 Microprobe Battery

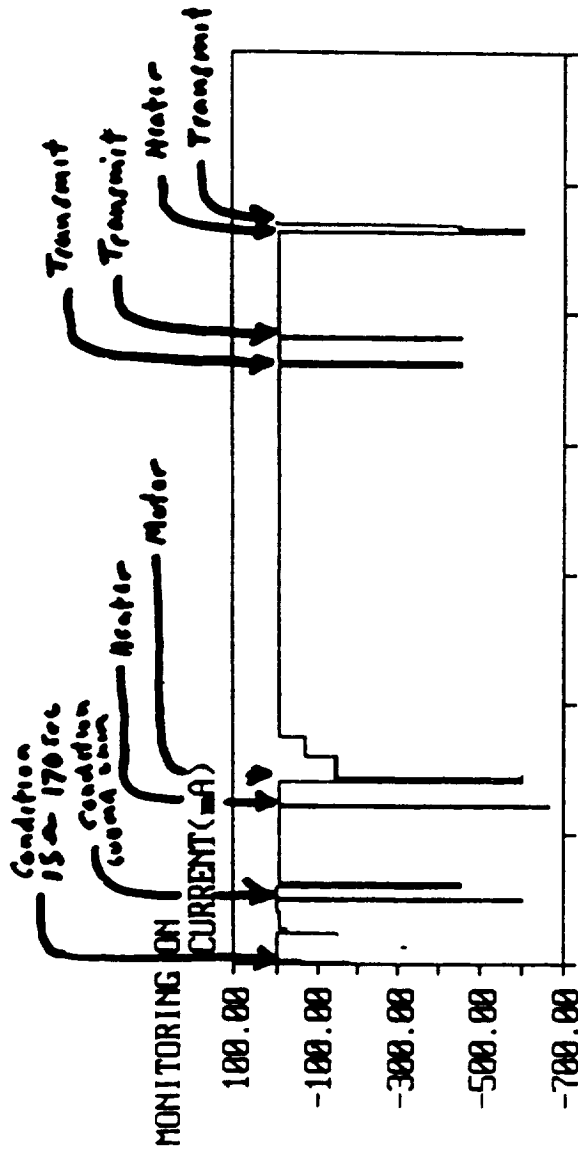


- Parallel Plate Configuration
Perpendicular to to cyl. Axis
- $\text{LiGaCl}_4/\text{SOCl}_2$ Electrolyte
- Thin Electrodes
- Tefzel Spacer to Provide Stack
Compression

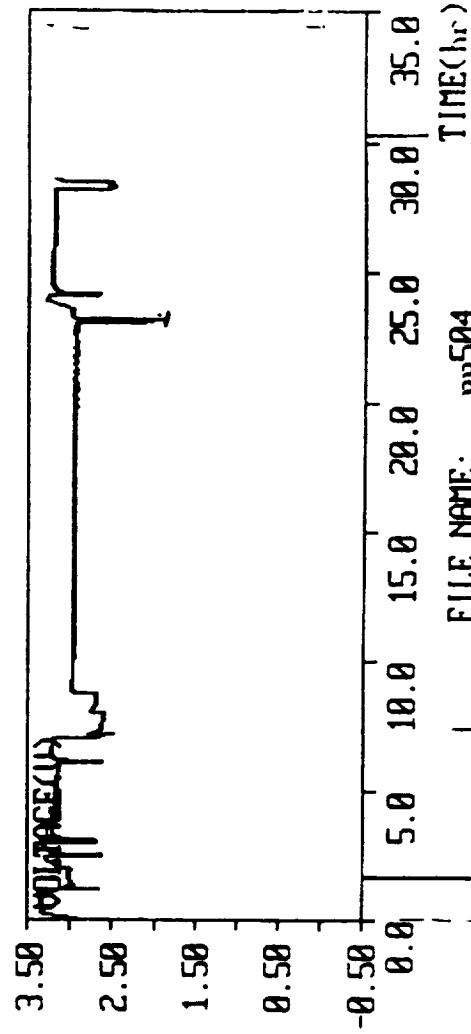
INDUSTRIAL PARTNER: YARDNEY TECHNICAL PRODUCTS

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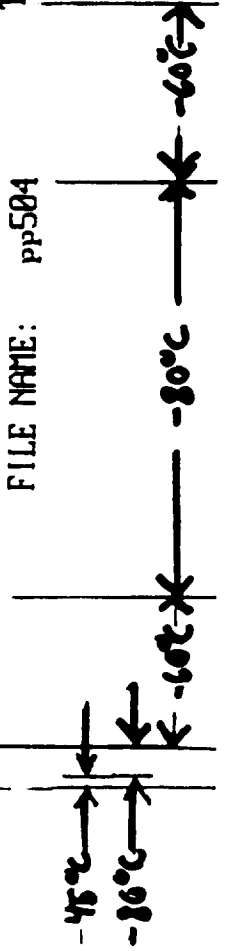
PROFILE TEST



Current
(mA)



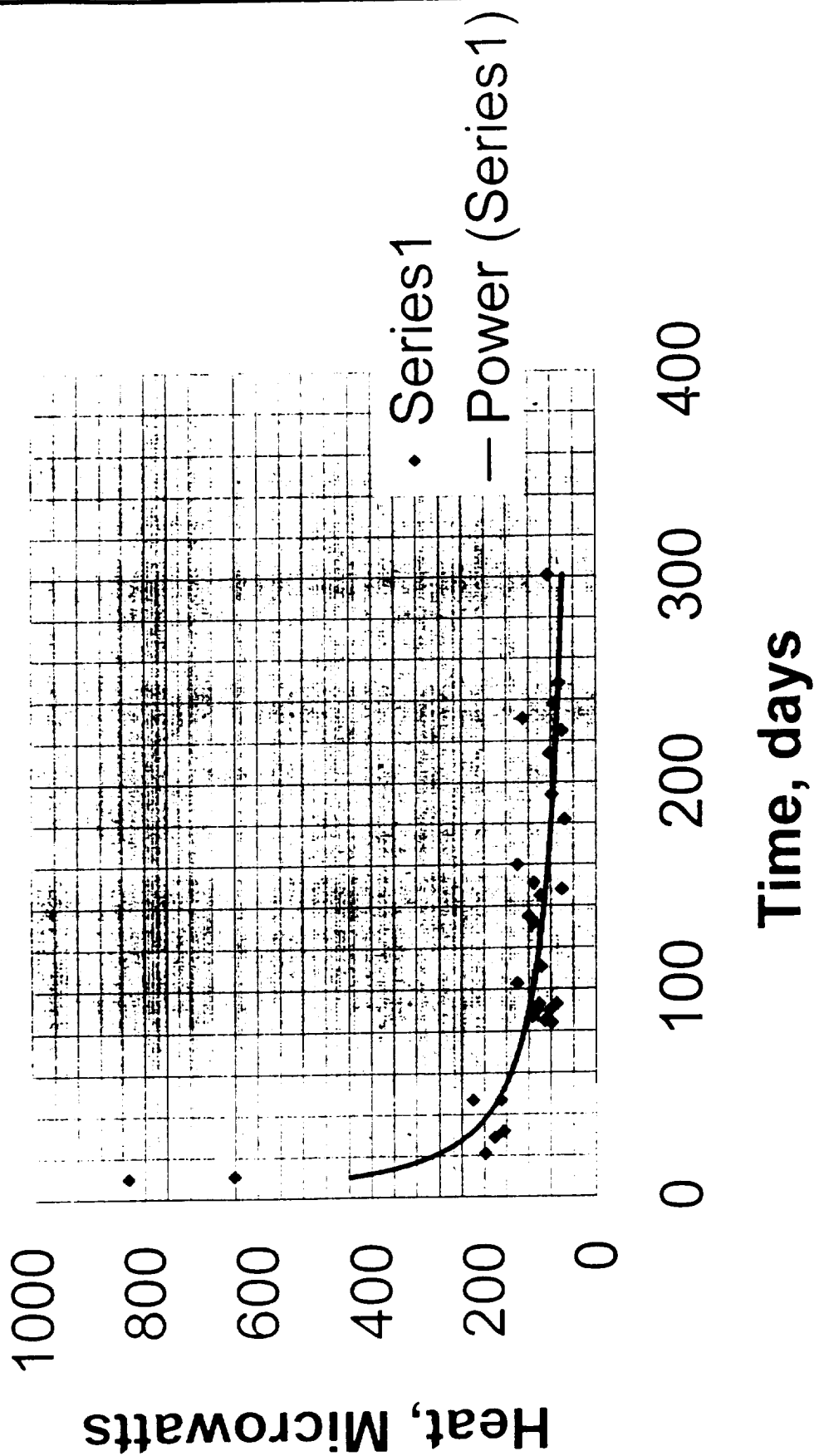
Voltage
(V)



Temp
(°C)

o Meets profile with conditioning

MICROCAL SUMMARY



o MAX LOSS RATE $\approx 100 \mu W = 26.9 \mu A = 0.2 AH/yr$



PROBLEMS ENCOUNTERED

- IMPACT SENSITIVITY
- CRACKING OF SEALS
- VOLTAGE DELAY



IMPACT TESTING

Problems Encountered

TEST	DATE	# Cells	CELL TYPE	PROBLEM
36	3/13/97	4	Old Design	Electrolyte Leak GTM Cracks Three Cells Functioned
38	4/4/97	2	Old Design	Electrolyte Leak GTM Cracks Two Cells Functioned
42	5/29/97	8	Old Design	Electrolyte Leak GTM Cracks Seven Cells Functioned
50	8/28/97	8	New Design	One Cell Vented, One Cell Bulged, Seven Cells Functioned
53	10/29/97	7	New Design	No Problems Electrochemical Technologies Group



SEAL PROBLEM



PROBLEMS

- RADIAL CRACKS(1-3) WERE OBSERVED IN THE GLASS TO METAL SEALS IN 34 OF 48 CELLS
 - FOURTEEN CELLS SHOWED NO CRACKS ON INSPECTION
 - CIRCUMFERENTIAL TOOL MARKS OBSERVED IN SOME SEALS
- ## CORRECTIVE ACTIONS

PRE WELD FILL TUBE

IMPROVED HEAT SINKING DURING CASE TO COVER WELD

CHANGE SEAL DIMENSIONS TO REDUCE STRESS

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VOLTAGE DELAY PROBLEM

PROBLEM

- Voltage delay in excess of 50 seconds was seen at temperatures lower than -45 C

CORRECTIVE SOLUTION

- Dry the Electrodes to Reduce Water Contamination
- Assemble the Cells within a Week of Electrode Manufacturing
- Ensure Electrolyte Purity (Iron, Water Content)
- Provide second depassivation pulse after landing

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DS-2 BATTERY ADDITIONAL TESTS SATIFIED

- **ENVIRONMENTAL**

- Thermal cycling, -30 to + 75oC.
- Quasi-static acceleration, 100g for 60 sec.
- Random vibration

- **SAFETY**

- Discharge and Reversal at 114 mA, and at 25 and -80oC.
- Shorting across 0.020 Ohms.



DS-2 BATTERY ACCOMPLISHMENTS

- **Demonstrated low temp (to -80°C) capability.**
- **Demonstrated capability to withstand shock.**
- **Demonstrated functionality for mission profile at low temp after shock.**
- **Demonstrated acceptably low self discharge for 2 year mission life.**
- **Delivered hardware and documentation.**

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DS-2 BATTERY CONCLUSIONS

- **Can withstand shock (to 80, 000 g).**
- **Can meet discharge profile post shock at Mars temps.**
- **Self discharge rate moderate but not excessive (0.2 Ah/year max).**
- **Can meet environmental requirements and tolerate electrical abuse.**



DS-2 BATTERY ACKNOWLEDGMENTS

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